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Special Scientific Report No. 56

OBSERVATIONS ON THE HORIZONTAL DISTRIBUTION AND THE NUMBERS OF EGGS AND LARVAE OF THE NORTHERN ANCHOVY (ENGRAULIS MORDAX) OFF CALIFORNIA IN 1940 AND 1941

by

John C. Marr and Elbert H. Ahlstrom

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INTRODUCTION

In 1939, 1940 and 1941, the U.S. Fish and Wildlife Service and the Scripps Institution of Oceanography carried out cooperative oceanographic surveys off the west coast of North America. The 1939 survey was carried out in the area lying between Cascade Head, Oregon, and Sebastian Viscaino Bay, Lower California, and extending as much as 340 miles offshore. The 1940 and 1941 surveys were confined to the area lying between Point Conception, California, and northern Lower California and extending 150 miles offshore. The Fish and Wildlife Service was interested primarily in the early life history of the pilchard, Sardinops caerulea (Girard 1854), while the Scripps Institution of Oceanography was interested in the chemical, physical and biological oceanography of the region surveyed. Oceanographic data resulting from these cruises have been published by Sverdrup and staff (1943, 1944, and 1947). Information on pilchard eggs and larvae has been published by Ahlstrom (1943, 1948) and Silliman (1943, 1946).

Plankton hauls, made primarily for pilchard eggs and larvae, naturally contained numerous other organisms. Of these, the eggs and larvae of the northern anchovy, 1/ Engraulis mordax Girard 1854, were often taken in large numbers.

A study of the biology of the northern anchovy undertaken in 1940 by the senior author was interrupted in its early stages and it becomes increasingly doubtful that it will be resumed. It seems desirable for several reasons that the data relating to the distribution and the numbers of anchovy eggs and larvae taken during these surveys be made available. Such data are presented in this report for the 1940 and 1941 surveys. Anchovy eggs and larvae were not completely sorted from the 1939 plankton collections.

Ahlstrom (1948) has presented information on the numbers of pilchard eggs and larvae taken on these surveys. He has also given descriptions of the station patterns, the gear employed, the methods of hauling nets, the methods used in sorting plankton, and the procedures followed in putting the hauls on a comparable basis. Hauls were standardized to 10 cubic meters of water strained per meter of depth fished by the nets. Such a standard haul "should be equivalent to a vertical haul taken from approximately 73 meters deep to the surface with a net having a cross-sectional area at the mouth of 10 square meters." Descriptive material given by Ahlstrom will not be repeated here and reference to the paper cited above is essential. In instances where it is necessary to present station data not given by him, the same style of presentation and notation will be used to facilitate cross reference.

1/ The common name of Engraulis mordax has recently been given as pacific anchovy by the American Fisheries Society's Committee on Common and Scientific Names of Fishes. (A list of common and scientific names of the better known fishes of the United States and Canada, Amer. Fish. Soc., Spec. Publ. no. 1, 45 pp., 1948) This species has been known officially as the northern anchovy for some time in California, at least. There seems to be little advantage in substituting a new name that is only slightly, if any, more descriptive.

IDENTIFICATION OF ANCHOVY EGGS AND LARVAE

Bolin (1936) described the development of Engraulis mordax eggs and larvae up through the volk sac stage (five days after hatching). Anchovy eggs were also described by Eigenmann (1893), who did not distinguish between E. mordax and Anchoa delicatissima (Girard 1854). Apparently the ellipsoidal fish eggs present in our collections are all referable to Engraulis mordax. With the aid of the descriptions of the early stages given by Bolin, it was relatively easy to recognize the larger larvae. The only other form present in these plankton collections with which the anchovy larvae might be confused is the pilchard. Ahlstrom (1948) has indicated the principal differences between these two species

1940 SURVEY

The plankton nets used during the 1940 survey, 1.6 meters in diameter at the mouth, were constructed of No. 24xxx grit gauze or of a cotton scrim of similar mesh-size. These materials had openings of .7 to .8 mm. between threads, which is considerably larger than the width of anchovy eggs and the smaller larvae. In consequence, only a small portion of the eggs and smaller larvae that entered the nets were retained. The retention of eggs was so poor that their numbers are not listed in the tables that follow. The numbers of larvae are given, although they are not quantitative for sizes smaller than about 9.0 mm. in total length. However, an idea of the distribution of the larvae and semiquantitative estimates of their abundance may be obtained from the data.

Because the volume of plankton taken in many hauls was large, only a fraction of the total volume, ranging from about 7 to 32 percent, was examined for eggs and larvae of all sizes. Estimates of the total number of larvae taken in a plankton haul were based on the numbers found in the fraction of the plankton sample actually examined. These estimated total numbers are expressed as numbers per standard haul in Table 1. Larvae of approximately 8.0 mm. and over were sorted from the remaining portions of the plankton samples from which eggs and larvae of all sizes had not been previously removed. If the size distribution of the larvae present in the plankton samples were known, it would be possible to correctly combine the numbers of larvae of all sizes present in a fraction of the total volume with the number of large larvae present in the remainder. Since the size measurements of the larvae were not made, only the numbers of larvae of all sizes as determined from the fractional samples are included in Table 1. However, in some of the samples no larvae were found in the first fraction examined and large larvae were found in the remainder of the sample. This situation is indicated in Table 1 by a plus sign. Of the 27 such occurrences, the actual number of large larvae sorted from the remainder of the plankton samples was 6 or less, except in three instances when 11, 24, and 25 were found.

1941 SURVEY

At about two-thirds of the stations occupied during the 1941 survey, two nets were towed together. The larger net, 1.0-meter in diameter at the mouth, was constructed of materials similar to those used the previous season. The smaller net, 0.5-meter in diameter at the mouth, was constructed of No. 40xxx grit gauze, which, after immersion, had openings of only 0.30 to 0.35 mm. between threads. At the remaining stations a net 1.0-meter in diameter at the mouth was used alone.

Because the smaller-sized nets used during the 1941 survey collected a smaller quantity of material than the nets used during the 1940 survey, a much larger portion of the samples was examined for eggs and the complete samples were examined for larvae of all sizes. Hence, the numbers of larvae taken per standard haul given in Table 2 are based on the numbers in the total volume of plankton, except for the few instances noted in the table. The numbers of eggs taken per standard haul are based in most instances on the numbers in 50% of the total volume of plankton. In some instances complete samples were examined for eggs. Where this was done, the standard haul total in Table 2 is followed by an asterisk. The 0.5-meter net plankton samples collected during cruises 25 and 27 have not been sorted.

We have assumed that no anchovy eggs or larvae were lost by the 0.5-meter net. Since the numbers of eggs and larvae in Table 2 are expressed in terms of standard hauls, the estimates for the two nets can be directly compared. The 1.0-meter net retained only 1.5 percent as many anchovy eggs as the 0.5-meter net. The retention of larvae of different size-groups cannot be compared since the larvae were not measured. On the basis of total counts, the 0.5-meter net retained about 3 times as many anchovy larvae as did the 1.0-meter nets.

STATION DATA

Data are given by Ahlstrom (1948) for the hauls taken in 1940 and 1941 in which pilchard eggs or larvae were found. For each haul there is listed the locality of hauling, time, net used, duration of haul, depth of haul, volume of water strained, and the standardization factor. Data for some of the hauls containing anchovy eggs or larvae but not pilchard eggs or larvae, are omitted from his list. Station data for these omitted hauls are given in Table 3 for the 1940 survey and in Table 4 for the 1941 survey.

APPARENT DIURNAL VARIATION IN THE DISTRIBUTION OF LARVAE

It has been noted that hauls taken during daylight contained markedly fewer pilchard larvae than hauls taken at night. To determine whether a similar relation obtained for anchovy larvae, the 1940 data were grouped into night hauls (7:30 P.M. to 4:30 A.M.) and day hauls (6:30 A.M. to 4:30 P.M.). The average number of larvae taken per night haul was 118, while an average of only 18 larvae were taken per day haul; on the average about six and one half times as many larvae were taken in a haul made after dark as in one made during daylight. There is substantial evidence on hand, based on data on vertical distribution, indicating that this difference is not due to the migration of larvae during the daylight hours below the zone fished by the nets. The taking of few anchovy larvae in day hauls, as compared with night hauls, is probably a reflection of the ability of the larvae to dodge the oncoming net during daylight hours.

Information on the vertical distribution of anchovy eggs and larvae will be presented in a separate paper.

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TABLE 1. Numbers of anchovy larvae taken per standard haul in 1940. (see text for explanation).

Station	Cruise #10	Cruise #11	Cruise #12	Cruise #13	Cruise #14	Cruise #15
1	246	222	35	64	46	35
2	21	143	18	44	58	0+
3	23	100	43	72	59	16
4	17	5	16	19	5	0+
5	13	5	0+	0	0+	0
6	--	0	0	0	6	0+
7	--	--	0	0	0	0
8	3	158	47	14	3	0+
9	2	7	0	0	3	--
10	178	126	33	5	7	0+
11	44	153	59	7	18	0+
12	242	28	--	6	45	0+
13	130	--	--	0	5	0
14	0	--	48	0	0+	0
15	0	--	7	3	0+	0
16	--	--	0	2	0+	0
17	22	82	75	47	99	4
18	0	--	--	15	3	--
19	37	147	22	7	3	0+
20	314	73	11	800	0	0
21	30	68	21	122	0+	0+
22	51	290	--	0	0+	3
23	7	51	60	0	0	0
24	12	74	--	0+	0	0
25	5	31	--	0	0	0
26	0	--	0	0	0+	0
27	0+	--	0	0	0	0
28	247	83	16	62	129	9
29	550	26	2	2230	30	0+
30	72	126	47	40	9	15
31	0+	39	41	0	3	0
32	0+	66	13	3	0	0+
33	0	--	6	0	0	3
34	20	113	65	61	13	0+
35	20	116	40	142	390	2
36	64	128	238	171	664	161
37	161	104	3	66	49	0+
38	10	26	97	44	11	0+
39	13	37	--	104	131	590
40	7	0+	6	6	259	13
41	--	--	--	--	0	--
42	--	--	--	--	0	0

TABLE 2. Numbers of anchovy eggs[1] and larvae[2] taken per standard haul in 1941.

	Cruise #17				Cruise #19			
	0.5-meter net		1-meter net		0.5-meter net		1-meter net	
Station	no. eggs	no. larvae	no. eggs	no. larvae	no. eggs	no. larvae	no. eggs	no. larvae
11	4087*	225	75*	111	105	507	6	37
12	18931	261	230	69	56	268	0	73
13	1247*	264	36*	67	--	---	0	24
14	--	--	87*	54	--	---	24	60[4]
15	34*	147	0	24	--	---	0	121[4]
16	4*	376	0	55	0	0	0	1
17	--	--	13	408	0	0	0	1
20	--	--	--	---	0	36	0	3
21	281*	463	10*	101	56	1118	0	285
22	--	--	7	36	35	147	7	20
23	--	--	84	58	2814*	1116	66*	58
24	--	--	72	46	--	---	4	13
25	--	--	50	120	274*	1180	2*	121
26	--	--	0	24	43*	809	0	80
27	--	--	0	26	0	78	0	12
28	--	--	0	91	29*	24	0	0
30	--	--	41	29	--	---	40	239
31	8*	292	0	90	0	441	0	19
32	499*	125	26*	38	261	357	2	240
33	3194*	58	42*	38	--	---	3	363
34	266*	146	15*	19	0	686	0	82
35	5*	355	1*	60	790	374	18	82
36	506	650	34	151	329*	641	43[3]	85
37	9	181	0	39	0	0	0	0
40	--	--	114	183	--	---	0	32
41	0	45	0	10	0	21	0	5
42	0	43[3]	0	4	133	197	0	27
43	4	63	0	28	0	174	0	134
44	0	64	0	44	4*	431	0	34
45	49	230	0	109	337*	161	0	34
46	--	--	0	39	1477	761	41	41
47	0	0	0	3	38	184	0	15
51	0	10	0	2	0	224[4]	0	133
52	0	5	0	3	0	129	0	104
53	0	28	0	11	0	1114	0	674
54	0	33	0	16	0	54	0	21
55	0	0	0	0	0	976	0	189
60	--	--	16*	0	--	---	10	228
61	0	134	0	26	0	67	0	33
62	0	9	0	4	0	87	0	63
63	0	0	0	2	0	72	0	71
64	0	4	0	1	0	1009	0	400

See page 10 for footnotes

TABLE 2. Numbers of anchovy eggs[1] and larvae[2] taken per standard haul in 1941 (cont'd).

	Cruise #21				Cruise #23			
	0.5-meter net		1-meter net		0.5-meter net		1-meter net	
Station	no. eggs	no. larvae	no. eggs	no. larvae	no. eggs	no. larvae	no. eggs	no. larvae
11	152	182	2	11	1213	360	2	77
12	665	131	6	16	1278	76	33	39
13	9165*	362	58*	74	---	---	51	1
14	---	---	2*	6	---	---	0	19
15	8308*	790	66*	119	---	---	0	0
16	---	---	2*	47	---	---	3	0
17	---	---	0	1	---	---	0	0
20	93	60	2	4	---	---	--	--
21	459	110	2	306	378	37	5	3
22	---	---	7	12	---	---	8	4
23	134*	65	2	4	25	28	0	2
24	---	---	53*	2	---	---	11	1
25	---	---	0	0	---	---	3	12
26	---	---	0	17	---	---	13	3
27	---	---	0	0	---	---	0	0
28	---	---	0	0	---	---	0	1
30	---	---	21*	49	---	---	0	1
31	0	17	0	7	11	5	0	10
32	0	19[4]	0	2	---	---	0	1
33	0	50	0	32	---	---	0	8
34	0	108	0	5	---	---	0	8
35	4537*	637	137*	67	---	---	0	98
36	81*	1091	1*	183	---	---	0	8
37	0	102	0	27	---	---	0	0
40	---	---	5	108	---	---	0	30
41	0	34	0	71	115	110	0	16
42	0	27	0	33	0	21	0	6
43	0	93	0	133	0	0	0	1
44	0	366	0	428	0	6	0	0
45	0	1834	0	1126	0	36	0	49
46	0	67	0	56	0	1550	0	408
47	0	626	0	106	0	364	0	5
51	0	18	0	23	0	148	0	31
52	0	11	0	5	0	114	0	63
53	0	49	0	685[5]	0	0	0	6
54	0	268	0	682[3]	0	18	0	0
55	0	1464	0	684	0	45	0	82
60	---	---	0	15	---	---	0	0
61	0	12	0	199	0	8	0	2
62	0	184[4]	0	6	0	12	0	2
63	0	19	0	6	0	23	0	28
64	0	5	0	5	0	4	0	12

See page 10 for footnotes.

TABLE 2. Numbers of anchovy eggs[1] and larvae[2] taken per standard haul in 1941 (cont'd)

Station	Cruise #25 1-meter net no. eggs	Cruise #25 1-meter net no. larvae	Cruise #27 1-meter net no. eggs	Cruise #27 1-meter net no. larvae
11	0	2	0	5
12	0	0	0	0
13	0	0	0	0
14	30	0	0	0
15	34	0	0	0
16	0	0	0	1
17	0	0	0	0
21	56	3	28	24
22	3	3	0	0
23	0	0	0	3
24	3	1	0	0
25	0	1	0	2
26	0	1	0	0
27	0	0	0	0
28	3	0	0	0
30	36	58	0	13
31	0	2	0	2
32	0	0	0	1
33	0	0	0	9
34	0	2	0	8
35	0	3	0	2
36	0	0	0	1
37	0	1	0	4
40	69	30	0	0
41	3	6	26	0
42	2	1	0	12
43	0	0	0	0
44	0	1	0	0
45	0	12	0	0
46	0	1	0	3
47	0	0	0	0
51	0	8	0	0
52	0	3	0	0
53	0	13	0	0
54	0	7	0	0
55	0	7	0	1
60	0	0	0	0
61	0	20	0	0
62	0	3	0	0
63	0	1	0	0
64	0	1	0	0

See page 10 for footnotes

Footnotes to Table 2

1/ All numbers of eggs are based on the examination of one-half the total volume of plankton unless marked by an asterisk. The latter indicates that the total volume of plankton was examined.

2/ All numbers of larvae are based on the examination of the total volume of plankton unless otherwise indicated by an additional footnote.

3/ Three-fourths of the total volume of plankton examined.

4/ One-half of the total volume of plankton examined.

5/ Approximate; many larvae fragmented.

TABLE 3. Record of oblique hauls made with plankton nets during cruises 10-15 in 1940 at stations not listed by Ahlstrom (1948). Column headings are the same as those used and defined by him.

Station	Position North Latitude	Position West Longitude	Date	Hour	Net Type	Duration of Haul	Depth, Meters	Volume of water Strained	S Factor
1433	32°25'	120°52'	V-20	1435	2M-CC	16.0	0-73	803.0	.454
				1455	2M-CC	16.0	0-72	791.0	.454
1503	33°43'	120°11'	VI-5	1940	2M-CC	30.0	0-83	1411.0	.585
1508	33°36'	119°17.5'	VI-5	0900	2M-CC	17.0	0-66	1013.0	.325
				0920	2M-CC	19.0	0-69	1062.5	.321
1511	33°29'	119°17.5'	VI-5	0420	2M-CC	16.0	0-73	786.5	.463
				0440	2M-CC	17.0	0-76	857.5	.442
1519	33°25.5'	117°52'	VI-3	0500	2M-CC	17.0	0-71	621.5	.568
				0520	2M-CC	16.0	0-75	552.0	.676
1520	33°09'	118°15'	VI-2	1300	2M-CC	17.0	0-83	646.5	1.266
1528	33°06.5'	117°35'	VI-2	2315	2M-CC	15.0	0-74	868.0	.424
				2345	2M-CC	15.0	0-79	569.5	.685
1529	32°54.5'	118°00.5'	VI-2	1755	2M-CC	14.0	0-80	710.5	.424

TABLE 4. Record of oblique hauls made with plankton nets during odd-numbered cruises 17-27 in 1941, at stations not listed by Ahlstrom (1948). Column headings are the same as those used and defined by him.

Station	Position North Latitude	Position West Longitude	Date	Hour	Net Type	Duration of Haul	Depth, Meters	Volume of water Strained	S Factor
1742	32°58'	117°51'	III-30	1200	0.5M SF	23.0	0-71	151.8?	4.68
1920	33°36.5'	118°22.5'	IV-21	1205	0.5M SF	24.0	0-78	151.2?	5.17
					1M CC			517.1	1.51
2120	33°38.5'	118°24.5'	V-14	1240	0.5M SF	23.5	0-69	164.8	3.73
					1M S			883.9	0.78
2313	33°43'	120°08.5'	VI-4	0700	1M CC	25.0	0-76	596.7?	1.28
2328	33°02.5'	121°21'	VI-5	1645	1M CC	23.5	0-80	523.5?	1.52
2330	33°35.5'	118°10'	VI-3	0850	1M CC	11.0	0-29	280.1?	1.04
2331	33°20'	118°07'	VI-8	0045	0.5M SF	26.0	0-74	143.4	5.18
					1M C			607.5	1.22
2361	32°08.5'	117°13.5'	VI-12	0935	0.5M SF	23.0	0-72	176.6	4.06
					1M C			722.0	0.99
2511	33°53'	119°19'	VI-26	1450	1M C	24.0	0-79	502.0	1.57
2521	33°38'	118°39.5'	VI-26	0115	1M C	23.0	0-74	472.9	1.57
2522	33°35.5'	119°00.5'	VI-26	0530	1M CC	24.0	0-76	572.8?	1.33
2524	33°25'	119°44'	VI-26	2250	1M CC	25.0	0-77	584.5?	1.32
2526	33°14'	120°30'	VI-28	1455	1M CC	24.5	0-74	608.7?	1.21
2531	33°20'	118°09.5'	VI-29	1030	1M C	24.0	0-71	685.0	1.03
2534	33°02'	119°18'	VI-29	2245	1M C	24.0	0-75	607.5	1.24
2541	33°03.5'	117°31'	VI-25	1140	1M C	23.0	0-75	620.6	1.21
2542	32°56'	117°51'	VII-1	1105	1M C	23.5	0-73	720.5	1.01
2544	32°42'	118°40'	VII-1	0305	1M C	23.0	0-73	507.6	1.44
2546	32°29'	119°26'	VI-30	1905	1M C	24.0	0-72	617.1	1.17
2562	32°05'	117°40'	VII-2	2245	1M CC	23.0	0-77	534.9?	1.45
2563	31°58'	118°00'	VII-2	1900	1M C	23.0	0-75	602.4	1.25
2564	31°50'	118°24'	VII-2	1350	1M C	24.0	0-75	624.2	1.21
2711	33°55'	119°20'	VII-23	0610	1M S	24.0	0-72	599.4	1.21
2721	33°38.5'	118°37'	VII-22	2330	1M S	23.5	0-71	624.4	1.14
2723	33°29.5'	119°22'	VII-25	0900	1M S	24.0	0-71	740.7	0.95
2725	33°21'	120°06.5'	VII-25	0215	1M S	23.5	0-69	696.9	0.97

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TABLE 4. Record of oblique hauls made with plankton nets during odd-numbered cruises 17-27 in 1941, at stations not listed by Ahlstrom (1948). Column headings are the same as those used and defined by him. (Cont'd)

Station	Position North Latitude	Position West Longitude	Date	Hour	Net Type	Duration of Haul	Depth, Meters	Volume of water Strained	S Factor
2730	33°36'	118°10'	VII-22	1920	IM 60	9.0	0-23	254.4?	0.92
2731	33°20.5'	118°07'	VII-22	1630	IM S	23.5	0-74	743.6	1.00
2732	33°13.5'	118°28.5'	VII-25	1725	IM S	24.0	0-72	701.8	1.03
2733	33°08'	118°53'	VII-25	2110	IM S	23.0	0-75	657.1	1.14
2734	33°02.5'	119°17'	VII-26	0120	IM S	24.5	0-73	630.8	1.16
2735	32°57'	119°38.5'	VII-26	0510	IM S	24.0	0-77	808.7	0.95
2736	32°51'	120°03'	VII-26	0915	IM S	23.0	0-72	742.6	0.98
2737	32°42'	120°23.5'	VII-26	1300	IM S	24.5	0-80	667.9	1.19
2742	32°58.5'	117°55.5'	VII-22	0400	IM S	24.5	0-72	610.2	1.17
2746	32°28.5'	119°25.5'	VII-26	2240	IM S	23.0	0-73	692.6	1.05
2755	32°06'	118°51'	VII-28	0315	IM S	24.5	0-74	743.4	1.00